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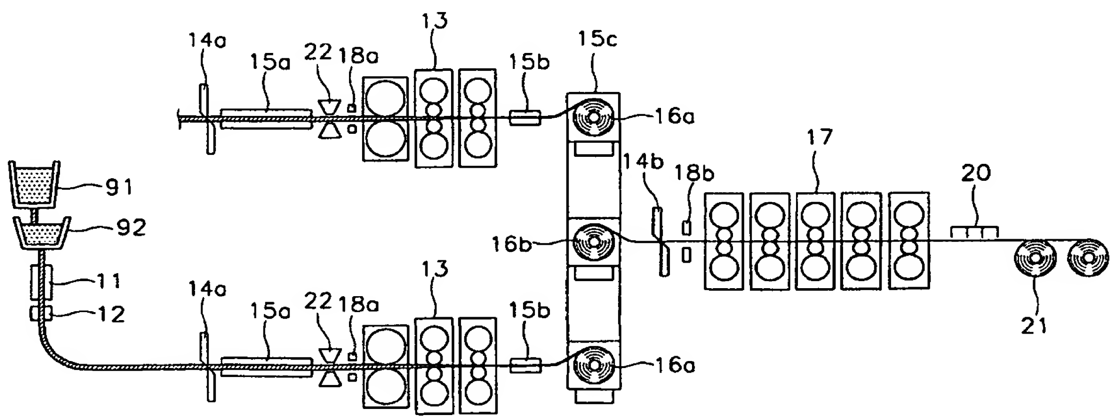

(57) Abstract

Disclosed is a method for manufacturing hot rolled steel sheets. The method includes the steps of passing molten steel through a continuous caster (11) having a mold after having been passed through a ladle (91) and a tundish (92) to manufacture a slab; cutting the slab to predetermined lengths using a cutter (14a) to form a plurality of cut slabs; heating the cut slabs to a predetermined temperature in a first heating furnace (15a) descaling the cut slabs heated in the first heating furnace; rolling the slabs in a reduction unit (13) to a predetermined thickness to form a plurality of flat bars; heating the flat bars to a predetermined temperature in a second heating furnace (15b); coiling the flat bars by a coiling station (16a) while the flat bars are maintained in a heated state; uncoiling the flat bars by an uncoiler (16b); and rolling the flat bars to a predetermined thickness in a finishing mill.

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METHOD OF MANUFACTURING HOT ROLLED STEEL SHEET USING MINI MILL PROCESS

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a method of manufacturing hot rolled steel sheets using a mini mill process, and more particularly, to a method in which ultra-thin strip production of hot rolled steel sheets is possible using a mini mill process.

(b) Description of the Related Art

In the mini mill steel making process, the final product is produced in a minimal amount of time using directly connected, short processes starting from a continuous casting process to a rolling process. Accordingly, the mini mill steel making process differs significantly from the blast furnace steel making process.

Although there are many types of mini mill processes, they can be generally divided into two categories depending on the thickness of the resulting slab: a thin slab process in which slabs of less than 70mm in thickness are produced, and a medium slab process in which slabs of greater than 70mm in thickness are produced. Also the mini mill process can be divided into two categories depending on the heating and rolling methods used.

As far as the actual method of production is concerned, the typical mini mill processes include the ISP (in-line strip production) process, the CSP (compact strip production) process and the Danieli process .

FIG. 4 shows a schematic view of an ISP process production line. With reference to the drawing, molten steel contained in a ladle 91 is poured into a tundish 92, then passes through a continuous caster 101, having a 75mm mold, and a liquid core reducer 102. Passing through the continuous caster 101, the molten steel is cast into slabs having a thickness of roughly 60mm. The slabs, without first being cut to a predetermined length, are descaled in a first descaler 108a, then directly rolled in a reduction unit 103 to produce flat bars having a

thickness of 20-30mm.

After passing through the reduction unit 103, the flat bars are cut to suitable lengths by a first cutter 104a. The cut flat bars are then heated in a heating furnace 105 and coiled in a coiling station 106a. Subsequently, the coiled flat bars are uncoiled in an uncoiler 106b then descaled in a second descaler 108b. Following this process, the flat bars are rolled in a finishing mill 107 to a predetermined final thickness, after which the flat bars are cooled in a cooler 120 and finally coiled in a down coiler 121. Reference numeral 104b in FIG. 4 refers to a second cutter.

In the ISP process described above, since the first cutter 104a is connected downstream from the reduction unit 103, the continuous caster 101 and the reduction unit 103 are in effect connected through the slabs being passed therethrough. Thus it is difficult to control the overall process. Further, since the high temperature slabs cast in the continuous caster 101 are rolled in the reduction unit 103, there will be a possibility of the reduction unit 103 to be deformed by the temperature of the slabs. In addition, the cast slabs are directly rolled in the reduction unit 103 without any heating. As a result, a difference in temperature between edges and a center of the slabs may occur, causing surface defects in the slabs.

In addition, since descaling is performed in the first descaler 108a immediately following continuous casting, optimal descaling is not achieved. That is, because a scale thickness is limited and there is only a small number of pores on a scale layer, a bonding force between the scales and matrix of the slabs is very high.

With regard to the CSP process, with reference to FIG. 5, molten steel contained in a ladle 91 is poured into a tundish 92 as in the ISP process described above. The molten steel is cast into slabs after passing through a continuous caster 201 and a liquid core reducer 202. The slabs are then cut to suitable lengths by a cutter 204. The cut slabs are heated in a heating furnace 205 having a length of at least 170m. In the heating furnace 205, the slabs are heated to a temperature suitable for rolling. Following this step, the heated slabs

are descaled by a descaler 208 then rolled by six rollers, after which the rolled slabs are cooled by a cooler 220 then coiled by a coiler 221.

In the CSP process described above, because of the considerable length of the heating furnace 205, up to three slabs can be positioned therein at one time. This increases manufacturing productivity. Additionally, since the slabs produced in another continuous caster (not shown) are not directly transmitted to the rollers 207, the heating furnace 205 has to be rotated or moved to feed the slabs into the rollers 207. Another feature of the CSP process is that a reduction unit is not required as in the CSP process since slabs of less than 50mm in thickness are produced by the continuous caster 201.

However, a drawback of the CSP process is that productivity lags behind other methods which manufacture slabs of medium thickness since casting is done at a faster rate than needed to produce slabs of medium thickness.

Referring now to FIG. 6, illustrating a schematic view of the Danieli process production line, after molten steel in a ladle 91 is poured into a tundish 92, the molten steel being solidified undergoes soft reduction in a 90mm mold of a continuous caster 301 and a liquid core reducer 302 such that slabs of 70mm in thickness are produced. The slabs are then cut to suitable lengths by a first cutter 304a. The cut slabs are descaled in a first descaler 308a then heated to a temperature suitable for rolling in a first heating furnace 305. The first heating furnace 305 has a substantial length so that a plurality of slabs can be heated therein at one time.

Because medium slabs are manufactured in the Danieli process, both a roughing mill 303 and a finishing mill 307 are provided. That is, after the slabs are rolled into flat bars by the roughing mill 303, the flat bars undergo rolling also in the finishing mill 307. A heated cover 305b is provided between the roughing mill and finishing mills 303 and 307 to ensure that the flat bars are maintained at an appropriate temperature before being supplied to the finishing mill 307. The length of the heated cover 305b is determined depending on a length of one flat bar. After rolled in the finishing mill 307, the flat bars are

cooled by a cooler 320 then coiled by a final coiler 321. Reference numeral 322 in FIG. 6 refers to a width roller, and reference numerals 304b, 308b and 308c refer respectively to a second cutter, a second descaler and a third descaler.

In the Danieli process as described above, because of the extensive length of the heated cover 305b (equal to the length of one slab), an overall length of the Danieli production line is increased.

SUMMARY OF THE INVENTION

The present invention has been made in an effort to solve the above problems.

It is an object of the present invention to provide a method of manufacturing hot rolled steel sheets using a mini mill process in which it is easy to control the process, high descalability and ability to easily realize width rolling are achieved, and the production of ultra-thin strips of hot rolled steel sheets is possible.

To achieve the above object, the present invention provides a method of manufacturing hot rolled steel sheets using a mini mill process. The method includes the steps of passing molten steel through a continuous caster having a mold after having been poured into a ladle and a tundish to manufacture a slab; cutting the slab to predetermined lengths using a cutter to form a plurality of cut slabs; heating the cut slabs to a predetermined temperature in a first heating furnace; descaling the cut slabs heated in the first heating furnace; rolling the slabs in a reduction unit to a predetermined thickness to form a plurality of flat bars; heating the flat bars to a predetermined temperature in a second heating furnace; coiling the flat bars by a coiling station while the flat bars are maintained in a heated state; uncoiling the flat bars by an uncoiler; and rolling the flat bars to a predetermined thickness in a finishing mill.

According to a feature of the present invention, the slabs are heated to a temperature 1000°C and above by the first heating furnace.

According to another feature of the present invention, the slabs are

heated to a temperature between 1000 and 1200°C for 5-6 minutes by the first heating furnace.

According to yet another feature of the present invention, the slabs undergo width rolling before being descaled and after being heated by the first heating furnace.

According to still yet another feature of the present invention, the slabs being rolled in the reduction unit are maintained to a temperature between 800 and 1000°C at an output of the reduction unit.

According to still yet another feature of the present invention, the slabs casted in the continuous caster undergo liquid core reduction.

According to still yet another feature of the present invention, a thickness of the slabs casted in the continuous caster is 100mm, and the slabs undergo liquid core reduction to a thickness of 80mm.

In another aspect, after the flat bars are uncoiled by the uncoiler, the flat bars are cut to a predetermined length; ends of the flat bars are joined; the flat bars are rolled to a predetermined thickness in the finishing mill; and the flat bars are cut to a predetermined length.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the description, serve to explain the principles of the invention:

FIG. 1 is a schematic view of a production line for a mini mill process according to a first preferred embodiment of the present invention;

FIG. 2 is a schematic view of a production line for a mini mill process according to a second preferred embodiment of the present invention;

FIG. 3 is a graph illustrating at which relation between an isothermal maintenance time and an isothermal maintenance temperature edge crack occurs;

FIG. 4 is a schematic view of a production line for a conventional ISP

mini mill process;

FIG. 5 is a schematic view of a production line for a conventional CSP mini mill process; and

FIG. 6 is a schematic view of a production line for a conventional Danieli mini mill process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. 1 shows a schematic view of a production line for a mini mill process according to a first preferred embodiment of the present invention. Molten steel is poured into a ladle 91 and a tundish 92 continuously, then passed through a continuous caster 11 having a mold such that the molten steel is manufactured into a continuous slab. It is also possible to provide a liquid core reducer 12 downstream from the continuous caster 11 where the continuous slab undergoes reduction. The mold of the continuous caster 11 is a straight parallel mold.

The mold of the continuous caster 11 preferably has an interval of approximately 100mm. This is done to minimize an output opening of the mold taking into consideration a refractory life, and to minimize an amount and speed of output flow such that a temperature of the molten steel in the mold is maintained at a uniform level. Accordingly, a high degree of quality can be ensured. Further, it is preferable that the liquid core reducer 12 performs an approximately 20mm core reduction. In this way, by controlling conditions of the continuous casting and the liquid reduction, a slab of approximately 80mm is produced such that load given to a roller is reduced and quality is improved.

A first cutter 14a is provided upstream from a first heating furnace 15a. The first cutter 14a cuts the slabs to predetermined suitable lengths such that the continuous casting process and a subsequent rolling operation are independently performed such that control problems do not occur and greater

stability is achieved. The cut slabs pass through the first heating furnace 15a, where the slabs are heated to a temperature suitable for rolling, after which the slabs are rolled in a reduction unit 13. Here, it is preferable that the heating temperature is over 1000^{0}C, and more preferably between 1000 and 1200^{0}C. Further, it is preferable that the slabs are heated at the preferred temperature for approximately 5-6 minutes.

The reason for heating the slabs before being rolled in the reduction unit 13 will now be described. Since S (sulfur) solubility of austenite is extremely low, during the phase transformation of $\delta \rightarrow \gamma$, S is segregated on grain boundaries, and S and Fe react to form FeS, and the FeS reacts with the Fe to form Fe-FeS. Because the Fe-FeS on a grain boundary exists as a liquid at approximately 988^{0}C, grain boundary strength is reduced such that cracks occur during rolling.

However, in the case where Mn (manganese) is contained in steel, when S of the grain boundaries is precipitated into MnS, brittleness disappears. Mn + S $\rightarrow$ MnS precipitation and growth reaction are determined by diffusibility of Mn, and if maintained for approximately 10 minutes at 1050^{0}C, over 70% of S is precipitated into MnS.

Accordingly, in the present invention, the slabs are heated to the conditions as described above before being rolled by the reduction unit 13 so that during the phase transformation of $\delta \rightarrow \gamma$, S, which is segregated on grain boundaries, does not react with Fe, but rather with Mn to form MnS, thereby preventing the formation of cracks during rolling.

The slabs heated as in the above then undergo descaling by a first descaler 18a before being rolled by the reduction unit 13. Since the slabs are descaled in the present invention after being heated, rather than immediately following continuous casting, this descaling operation can be effectively carried out. That is, after heating the slabs, scales on the slabs are thick and a number of pores thereon are high such that a bonding force between the scales and the slabs is weak, thereby enabling easy descaling of the slabs.

Preferably, a width roller 22 is mounted upstream from the first descaler 18a for varying a width of the slabs before the varying operation. At this time,

the width of the slabs is rolled to an amount corresponding to a thickness of the slabs, and the width roller 22 enables the width of the slabs to be rolled up to roughly 14-15mm. Further, by the width rolling of the slabs before the descaling operation, cracks are formed on the scales such that the subsequent descaling of the slabs is improved.

Following the above, the descaled slabs are rolled in the reduction unit 13. At this time, a rolling amount and a number of roller stands used are determined by considering a desired thickness of the final product. Preferably, the reduction unit 13 includes three stands that are structured such that an 80mm slab enters the reduction unit 13 and is formed into 15-30mm flat bars. Here, it is possible for the reduction unit 13 to include only two stands to form 20-30mm flat bars. Flat bars exiting the reduction unit 13 are at a temperature between 800 and 1000°C.

A second heating furnace 15b is provided downstream from the reduction unit 13. The second heating furnace 15b heats the flat bars exiting the reduction unit 13 to a temperature between 1030 and 1080°C such that a finishing mill 17 can more easily roll the flat bars, thereby enabling the economic manufacture of ultra-thin strips. Here, in order to more effectively heat the flat bars, it is preferable to use an inductive heater for the second heating furnace 15b. In the case where an inductive heater is utilized, output of the inductive heater is determined by the degree to which the temperature of the flat bars is increased, the inductive heater being flexibly used depending on an output temperature of the reduction unit 13. Preferably, an extractor is mounted in the second heating furnace 15b to extract defective, particularly start and end defective slabs.

The flat bars heated by the second heating furnace 15b are then coiled in a coiling station 16a. It is preferable that the coiling station 16a is mounted in a holding furnace 15c so that the temperature to which the flat bars are raised by the second heating furnace 15b can be maintained. Preferably, a size of the holding furnace 15c is such that it can hold about 8-10 bar coils at one time so that if problems occur in the finishing mill 17, the continuous caster 11 can

proceed with its casting operation and does not need to be stopped.

The bar coils are then uncoiled in an uncoiler 16b before being supplied to the finishing mill 17 where the flat bars undergo a final rolling process. It is preferable that a second cutter 14b is provided between the uncoiler 16b and the finishing mill 17. The second cutter 14b cuts ends of the flat bars so that the final rolling process is proceeded without any interruption.

In addition, it is preferable that a second descaler 18b is provided immediately upstream from the finishing mill 17, between the second cutter 14b and the finishing mill 17. Further, since a number of stands of the finishing mill 17 determines a thickness of the final product, it is preferable to provide a total of 5 stands for the finishing mill 17 to enable the ultra-thin strip production of hot rolled steel sheets. Moreover, to ensure the high quality formation of the final product, it is preferable to maintain a predetermined roll interval. A formation controller (not shown) can be provided for this purpose. Also, it is preferable to provide a grinder (not shown) which grinds the rolls to control friction between edge portions of the rolls.

A cooler 20 is provided downstream from the finishing mill 17, and the flat bars rolled in the finishing mill 17 are supplied to the cooler 20 where the flat bars are cooled. Further, a down coiler 21 is provided downstream from the cooler 20. The flat bars cooled in the cooler 20 are coiled in the down coiler 21.

As shown in FIG. 1, the above first cutting process, first heating process, width rolling process, first descaling process, first rolling process, second heating process, and first coiling process can be simultaneously performed at a plurality of locations to increase productivity.

FIG. 2 shows a schematic view of a production line for a mini mill process according to a modified example of the first preferred embodiment of the present invention. In the drawing, identical reference numerals will be used for elements similar to those appearing in FIG. 1, and except for added elements, it is to be assumed that the elements appearing in both the drawings are identical in operation.

As shown in the drawing, a plurality of uncoilers 31 are provided

downstream from the coiling stations 16a. Further, a bar joiner 32 is provided downstream from the second cutter 14b, between the second cutter 14b and the second descaler 18b. The bar joiner 32 joins a rear end of a bar undergoing rolling in the finishing mill to a front end of a bar waiting to be rolled such that the flat bars can be continuously rolled. Finally, a high speed cutter 33 is provided between the cooler 20 and the down coiler 21 which cuts the flat bars cooled in the coiler 20 to suitable lengths. A structure of the plurality of uncoilers 31 is commonly known in the art.

FIG. 3 is a graph illustrating at which relation between an isothermal maintenance time and an isothermal maintenance temperature that edge crack occurs. As shown in the drawing, if maintained for a suitable amount of time at a temperature above 900°C, no edge crack occurs.

In the method of manufacturing hot rolled steel sheets using the mini mill process described above, since it is easy to control the process, high descalability and an ability to easily realize width rolling are achieved, and the production of ultra-thin strips of hot rolled steel sheets is possible, casting stability is ensured, the quality of the final product is improved, various different specifications can be catered to, and productivity is improved. Further, with the ability to perform casting on a non-stop basis, defects in the final product are reduced and the occurrence of the flying phenomenon can be prevented.

Although preferred embodiments of the present invention have been described in detail hereinabove, it should be clearly understood that many variations and/or modifications of the basic inventive concepts herein taught which may appear to those skilled in the present art will still fall within the spirit and scope of the present invention, as defined in the appended claims.

WHAT IS CLAIMED IS:

1. A method for manufacturing hot rolled steel sheets comprising the steps of:

passing molten steel through a continuous caster having a mold after having been poured into a ladle and a tundish to manufacture a slab;

cutting the slab to predetermined lengths using a cutter to form a plurality of cut slabs;

heating the cut slabs to a predetermined temperature in a first heating furnace;

descaling the cut slabs heated in the first heating furnace;

rolling the slabs in a reduction unit to a predetermined thickness to form a plurality of flat bars;

heating the flat bars to a predetermined temperature in a second heating furnace;

coiling the flat bars by a coiling station while the flat bars are maintained in a heated state;

uncoiling the flat bars by an uncoiler; and

rolling the flat bars to a predetermined thickness in a finishing mill.

2. The method of claim 1 wherein the slabs are heated to a temperature 1000°C and above by the first heating furnace.

3. The method of claim 2 wherein the slabs are heated to a temperature between 1000 and 1200°C for 5-6 minutes by the first heating furnace.

4. The method as in any one of claims 1-3 wherein the slabs undergo width rolling before being descaled and after being heated by the first heating furnace.

5. The method as in any one of claims 1-3 wherein the slabs being rolled in the reduction unit are maintained to a temperature between 800 and 1000°C at an output of the reduction unit.

6. The method of claim 4 wherein the slabs being rolled in the reduction unit are maintained to a temperature between 800 and 1000°C at an output of the reduction unit.

7. The method as in any one of claims 1-3 wherein the slabs casted in the continuous caster undergo liquid core reduction.

8. The method of claim 4 wherein the slabs casted in the continuous caster undergo liquid core reduction.

9. The method of claim 5 wherein the slabs casted in the continuous caster undergo liquid core reduction.

10. The method of claim 6 wherein the slabs casted in the continuous caster undergo liquid core reduction.

11. The method of claim 7 wherein a thickness of the slabs casted in the continuous caster is 100mm, and the slabs undergo liquid core reduction to a thickness of 80mm.

12. The method as in any one of claims 8-10 wherein a thickness of the slabs casted in the continuous caster is 100mm, and the slabs undergo liquid core reduction to a thickness of 80mm.

13. A method for manufacturing hot rolled steel sheets comprising the steps of:

passing molten steel through a continuous caster having a mold after having been poured into a ladle and a tundish to manufacture a slab;

cutting the slab to predetermined lengths using a first cutter to form a plurality of cut slabs;

heating the cut slabs to a predetermined temperature of a first rolling in a first heating furnace;

descaling the cut slabs heated in the first heating furnace;

rolling the slabs in a reduction unit to a predetermined thickness to form a plurality of flat bars;

heating the flat bars to a predetermined temperature of a second rolling in a second heating furnace;

coiling the flat bars by a coiling station while the flat bars are maintained in a heated state;

uncoiling a plurality of the flat bars by uncoilers;

rolling the flat bars to a predetermined thickness in a finishing mill while

a rear end of a bar steel undergoing rolling is joined to a front end of another bar steel waiting to be rolled such that the bar steels can be continuously rolled; and

cutting the flat bars to a predetermined length by a third cutter.

14. The method of claim 13 wherein the slabs are heated to a temperature 1000°C and above by the first heating furnace.

15. The method of claim 14 wherein the slabs are heated to a temperature between 1000 and 1200°C for 5-6 minutes by the first heating furnace.

16. The method as in any one of claims 13-15 wherein the slabs undergo width rolling before being descaled and after being heated by the first heating furnace.

17. The method as in any one of claims 13-15 wherein the slabs being rolled in the reduction unit are maintained to a temperature between 800 and 1000°C at an output of the reduction unit.

18. The method of claim 16 wherein the slabs being rolled in the reduction unit are maintained to a temperature between 800 and 1000°C at an output of the reduction unit.

19. The method as in any one of claims 13-15 wherein the slabs casted in the continuous caster undergo liquid core reduction.

20. The method of claim 16 wherein the slabs casted in the continuous caster undergo liquid core reduction.

21. The method of claim 17 wherein the slabs casted in the continuous caster undergo liquid core reduction.

22. The method of claim 18 wherein the slabs casted in the continuous caster undergo liquid core reduction.

23. The method of claim 19 wherein a thickness of the slabs casted in the continuous caster is 100mm, and the slabs undergo liquid core reduction to a thickness of 80mm.

24. The method as in any one of claims 20-22 wherein a thickness of the slabs casted in the continuous caster is 100mm, and the slabs undergo liquid core reduction to a thickness of 80mm.

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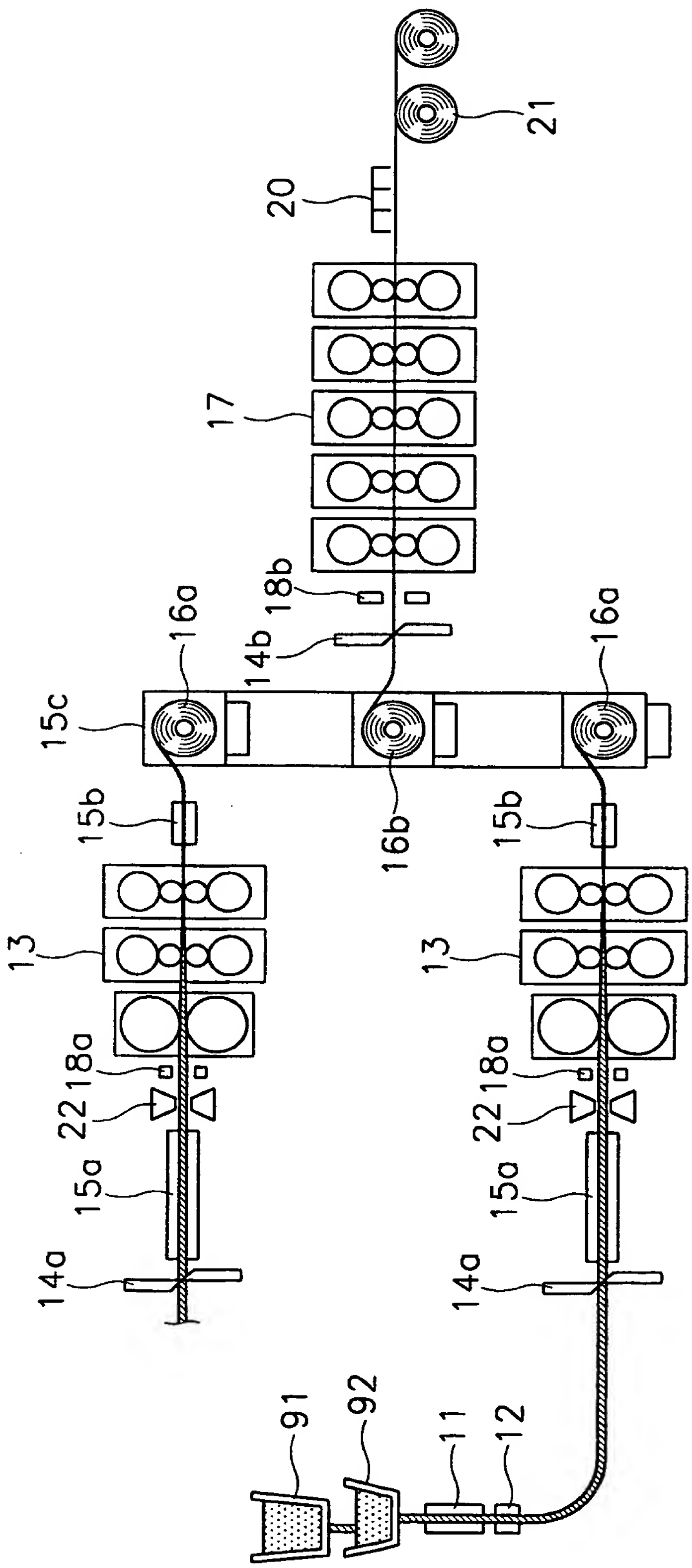
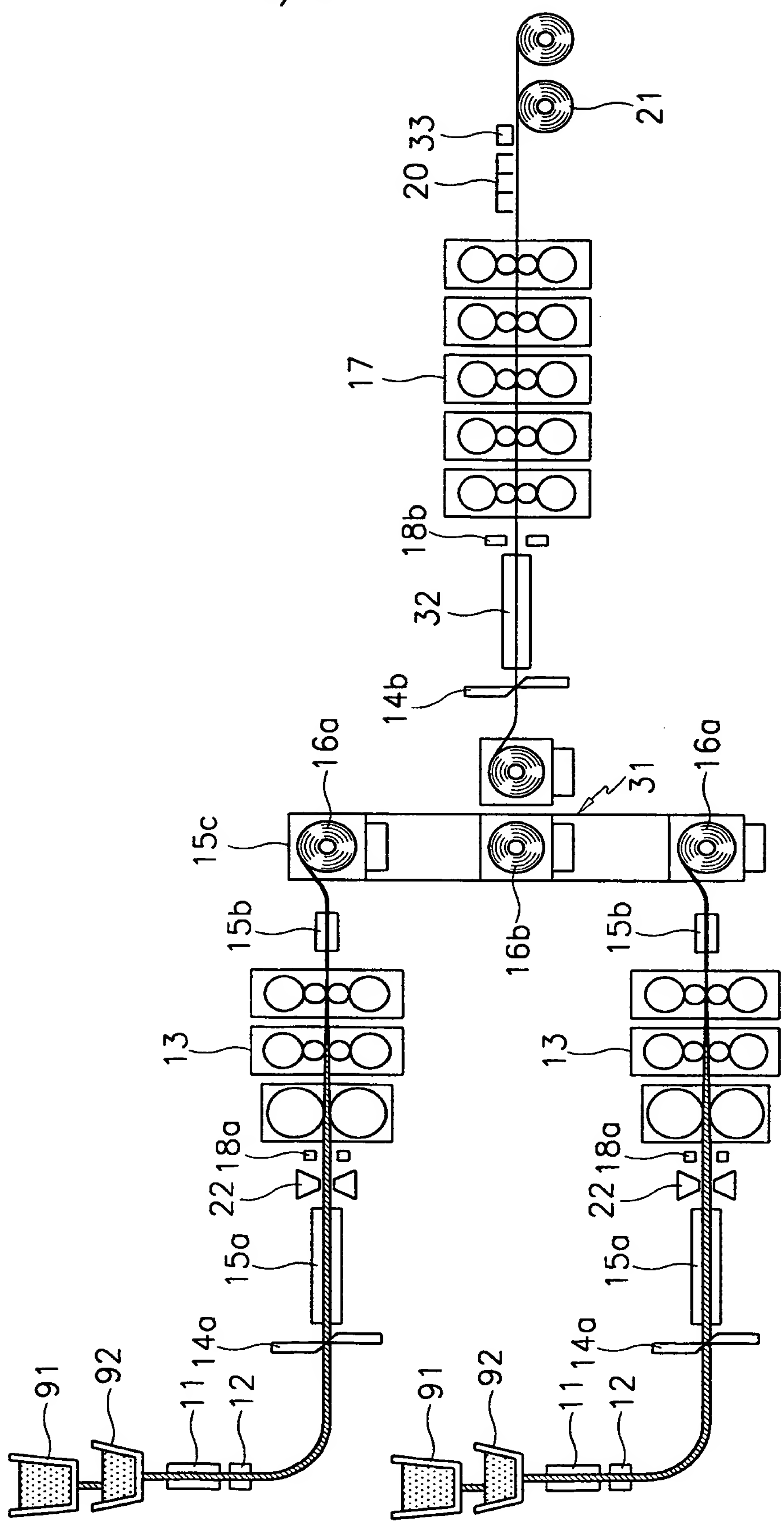


FIG.1


21
33
20
17
18b
32
14b
16a
31
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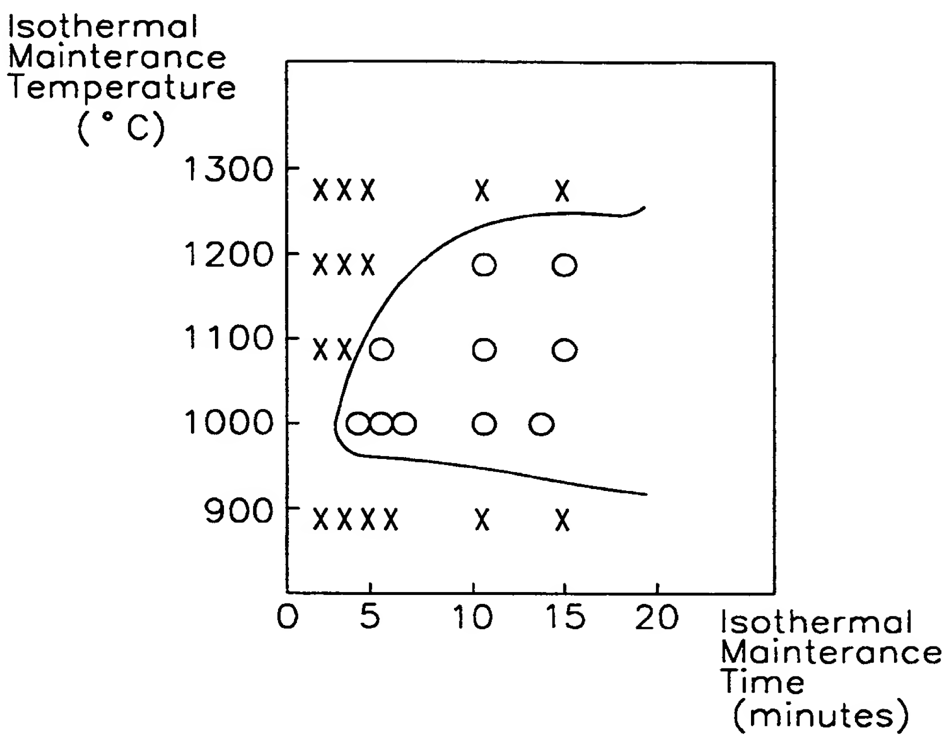
16b
15b
13
18a
22
15a
14a
91
92
11
12

FIG.2

FIG.3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(°C)
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1100
1000
900
X X X
X
X
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(minutes)

FIG.4 (Prior Art)

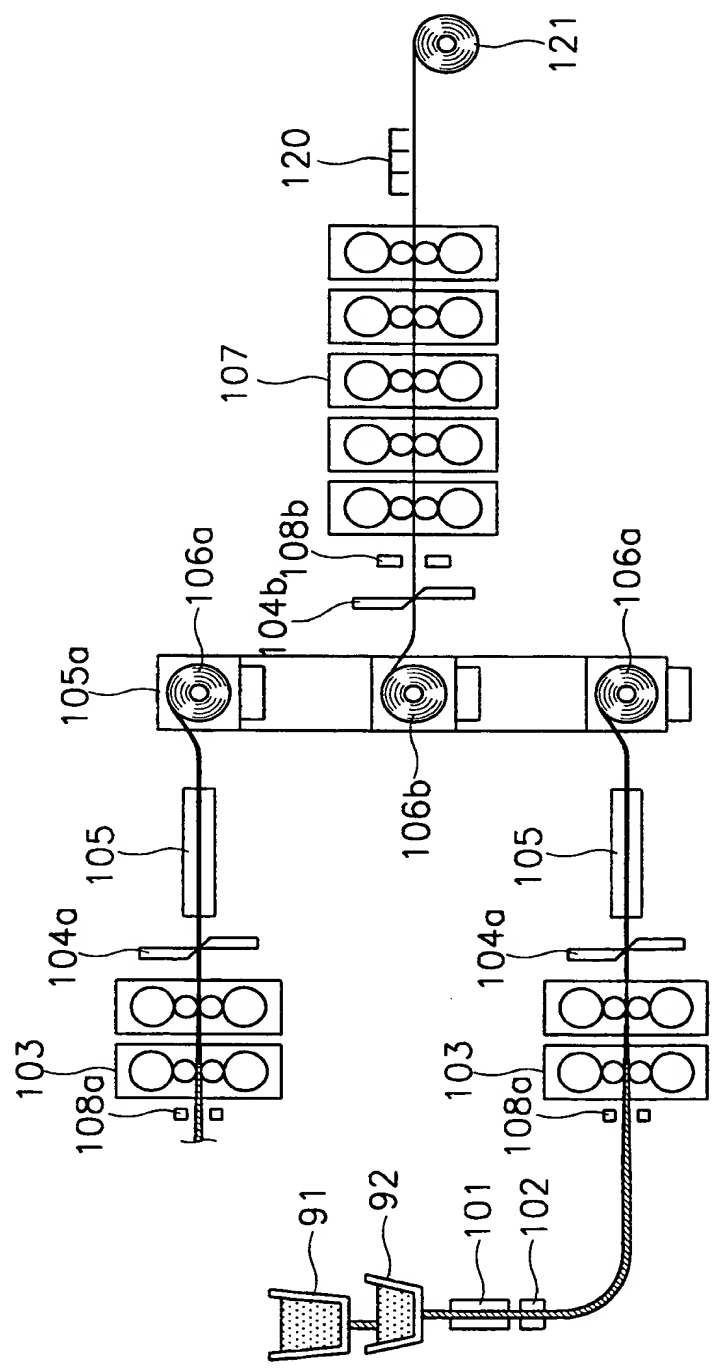


FIG.5 (Prior Art)

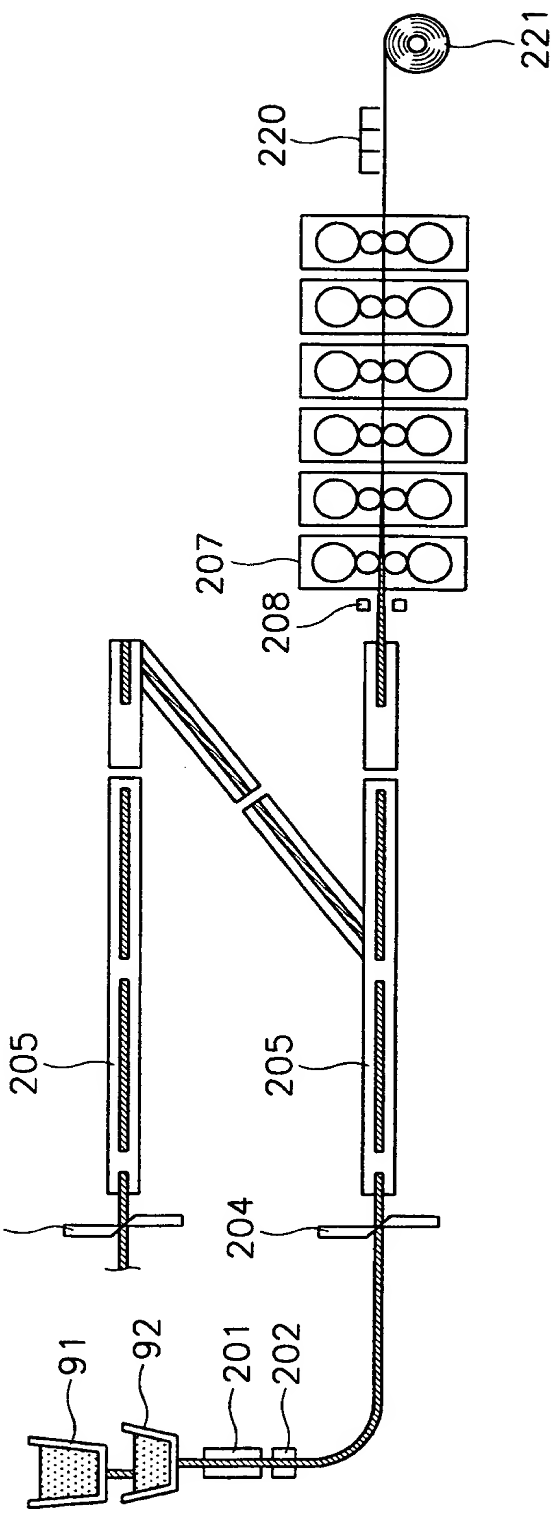
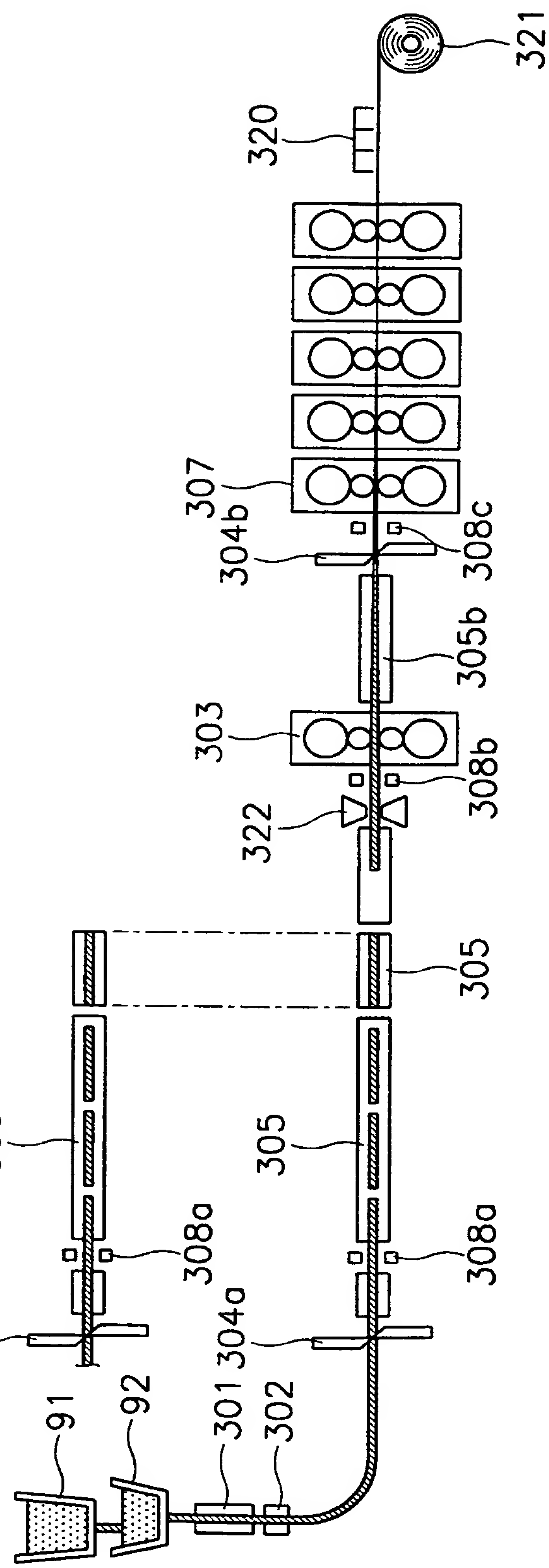


FIG.6

(Prior Art)



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 99/00102

A. CLASSIFICATION OF SUBJECT MATTER

IPC[7]: B 21 B 1/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: B 21 D 1/46

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Patentmanager, Epoque

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0674952 A1 (DANIELI & C.), 04 October 1995 (04.10.95), column 9, lines 39 - column 10, line 58 - column 11, line 29; claim 7; column 9, lines 25-30; fig.3-5.	1 2,3,5,6,13,14,15,18
Y	EP 0595282 A1 (SMS SCHLOEMANN SIEMAG), 04 May 1994 (04.05.94), column 2, lines 31-52; fig.4.	2,3,5,6,13,14,15,18
Y	EP 0770433 A1 (DANIELI & C.), 02 May 1997 (02.05.97), column 5, lines 1-6; fig.1.	4
A	WO 92/00815 A1 (ARVEDI), 23 January 1992 (23.01.92), claim 1; fig.	7-12,19-24

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 November 1999 (22.11.99)	09 February 2000 (09.02.00)

Name and mailing adress of the ISA/AT	Authorized officer
Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/200	Bistrich Telephone No. 1/53424/375

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP A1 674952	04-10-1995	AT E 176610	15-02-1999
EP B1 674952	10-02-1999	BR A 9501306	31-10-1995
		CN A 1114244	03-01-1996
		DE C0 69507729	25-03-1999
		DE T2 69507729	22-07-1999
		ES T3 2126801	01-04-1999
		IT A0 940051	31-03-1994
		IT A1 940051	02-10-1995
		IT B1 1267916	18-02-1997
		US A 5528816	25-06-1996
EP A1 595282	04-05-1994	AT E 131753	15-01-1996
EP B1 595282	20-12-1995	CA AA 2109397	29-04-1994
		CN A 1088491	29-06-1994
		DE A1 4236307	05-05-1994
		DE C0 59301206	01-02-1996
		JP A2 6198302	19-07-1994
		KR B1 9701550	11-02-1997
WO A1 9200815	23-01-1992	AT E 106286	15-06-1994
		AU A1 81007/91	04-02-1992
		AU B2 644889	23-12-1993
		BG B1 60451	28-04-1995
		BR A 9106630	20-04-1993
		CA AA 2085223	10-01-1992
		DE C0 69102280	07-07-1994
		DE T2 69102280	15-09-1994
		DK T3 541574	22-08-1994
		EP A1 541574	19-05-1993
		EP B1 541574	01-06-1994
		ES T3 2055608	16-08-1994
		FI A 925907	28-12-1992
		FI A0 925907	28-12-1992
		FI B 98896	30-05-1997
		FI C 98896	10-09-1997
		HU A0 9300031	28-04-1993
		HU A2 63081	28-07-1993
		HU B 211120	30-10-1995
		IT A0 9020884	09-07-1990
		IT A 1244295	08-07-1994
		JP T2 6503853	28-04-1994
		NO A0 924640	02-12-1992
		NO A 924640	07-01-1993
		NO B 176949	20-03-1995
		NO C 176949	28-06-1995
		RO B1 111166	30-07-1996
		RU C1 2070584	20-12-1996
		US A 5329688	19-07-1994
		ZA A 9105034	24-06-1992
		ZW A 80/91	18-09-1991
EP A1 770433	02-05-1997	CA AA 2188626	28-04-1997
EP B1 770433	12-01-2000	IT A0 950215	27-10-1995
		IT A1 950215	28-04-1997
		IT B1 1281442	18-02-1998
		US A 5970594	26-10-1999